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Sarcopenia screening of community-dwelling individuals aged 65 and over within the primary care setting

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Abstract.
BACKGROUND: The term sarcopenia, referring to declining function with age, has no universally agreed definition. Sarcopenia develops from multifactorial interactions, resulting in health problems such as frailty and increased falls risk; and for which screening may enable timely intervention. As sarcopenia screening equipment recommended by The European Working Group on Sarcopenia in Older People (EWGSOP2) is not always available in primary care, alternate screening strategies are needed.
OBJECTIVE: To investigate the efficacy of the SARC-CalF questionnaire for sarcopenia screening in primary care and agreement between SARC-CalF and SARC-F questionnaires, with EWGSOP2 cut-off values.
METHODS: Fifty community-dwelling adults aged 65yrs and over completed the SARC-CalF and EWGSOP2 strength and physical performance outcome measures. Calculations for probability of sarcopenia and skeletal muscle mass were completed. Agreement between operational definitions and outcome measures were assessed to establish screening accuracy.
RESULTS: Prevalence of probable sarcopenia ranged from 10–48% depending on outcome measure; SARC-CalF increased prevalence by 55% compared to SARC-F. Questionnaires agreed more strongly with probable sarcopenia as measured by leg than grip strength. Gait speed agreed significantly with strength and physical performance measures.
CONCLUSIONS: In community-dwelling adults aged 65yrs and over, outcome measure used influenced rates of probable sarcopenia. Within primary care, equations may enable assessment of muscle mass, while formulae may enable assessment of the probability of sarcopenia. Gait speed is recommended for quantification of sarcopenia severity.

Keywords: Sarcopenia, screening, primary care, elderly, SARC-CalF, muscle strength

1. Introduction

Sarcopenia was first recognised as a disease entity in 2016 [1] and is defined by numerous operational definitions incorporating muscle strength, muscle mass and physical function. Sarcopenia, effects daily function in adults due to increased frailty [2]. The European Working Group on Sarcopenia in Older People (EWGSOP2) [3] recommend early screening and treatment interventions for sarcopenia. Sarcopenia is caused by multifactorial interactions [4]. Primary sarcopenia occurs due to aging; after age 50, muscle mass declines 1–2% annually [5]; whilst secondary sarcopenia occurs due to co-morbidities, malnutrition or immobility [6].

In populations aged 65yrs and over the prevalence of sarcopenia ranges from 1.4% [7] to 87% [8]. The prevalence for Irish community-dwelling older adults is 7.1% using EWGSOP1 [6] and 5.5% using EWGSOP2 [3] algorithms respectively [9].

Sarcopenia is a strong prognostic indicator of negative health outcomes [10]. Sarcopenia has societal

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implications such as fractures and depression [11], reduced quality of life [12] and increased risk of cognitive impairment [13]. Sarcopenia increases falls risk [2]; the cost of fall related injuries in Ireland is estimated at €1.587-€2.043 billion by 2030 [14].

Inadequate nutrition [15] and reduced physical activity are major risk factors for development of sarcopenia [16]. As 39% of Irish people aged 56yrs and over report low physical activity levels [17], and Irelands population is aging [18], Ireland may experience increased rates of sarcopenia.

To prevent negative outcomes associated with sarcopenia; screening and assessment are important [19]. Primary care settings may provide assessment opportunities, complementing care provision in community settings [20]; and may enable case-finding or detection of those most at risk [21].

A variety of sarcopenia screening and testing procedures are used, including subjective questionnaires, objective measurements and equations. The most frequently used operational definitions are the EWGSOP1 [6] and EWGSOP2 [3] algorithms.

The EWGSOP2 recommend case-finding using the SARC-F questionnaire which assesses Strength, Assistance required walking, ability to Rise from a chair, ability to Climb stairs and Falls history [22]. Thereafter, EWGSOP2 recommend assessment of muscle strength using grip strength or the Chair Stand Test against probable sarcopenia cut-off points. Grip strength, a surrogate measure of more complex upper and lower limb strength measurements [3], is measured with a variety of techniques and cut-off points [7, 12, 23]. Lower limb strength is frequently assessed using the Chair Stand Test [8]. EWGSOP2 recommend assessment of muscle quality or quantity to confirm sarcopenia. EWGSOP2 then recommend analysis of sarcopenia severity using physical performance measures such as gait speed, Timed Up and Go (TUG) and the Short Physical Performance Battery (SPPB).

Calf circumference (CC), a frequently used anthropometric measurement, and a diagnostic proxy for muscle mass; is assessed using different techniques and cut-off points [8, 12, 24–26]. Recommended CC cut-off points for the population studied were unavailable.

Calculations [24, 27, 28] demonstrating high screening accuracy, highlight the possibility of assessing skeletal muscle mass (SMM) and screening for sarcopenia in primary care without the requirement for sophisticated equipment. The Ishii et al. [24] formulae incorporating age, grip strength and CC have high discriminative ability for sarcopenia. An equation for sarcopenia probability and score charts with alternative cut-offs depending on sensitivity and specificity requirements enable screening. Tonial et al. [23] used EWGSOP1 algorithm with an equation from Lee et al. [27] incorporating body weight, height, age, gender and ethnicity to calculate SMM.

Although the SARC-CalF screening questionnaire incorporating CC [29] and SARC-F are frequently used; case-finding among community-dwelling older adults using SARC-F is not supported [25, 26]; while SARC-CalF is recommended [25]. SARC-CalF has not been compared against the EWGSOP2 algorithm within the Irish population.

Consensus was not found in the literature regarding the most effective tool or clinical approach to screening. Analysis of which outcome measures agree with the probability of sarcopenia, could enable appropriate referral for investigations or interventions [30].

This study aimed to investigate the efficacy of using the SARC-CalF questionnaire with community-dwelling adults aged 65yrs and over. The key objectives were to screen for sarcopenia in primary care using the SARC-CalF and to assess agreement between the SARC-CalF with SARC-F, with EWGSOP2 strength and physical performance cut-off points, with Ishii et al. [24] formulae and with the SMM equation from Lee et al. [27] when screening individuals for probable sarcopenia.

2. Methods

2.1. Participants

This cross-sectional, quantitative study included a non-probability convenience sample of 34 females and 16 males. A pragmatic recruitment strategy involving general practitioners (GP's), a day care centre manager and chartered physiotherapists minimised recruitment bias as the principal investigator was not actively involved in recruitment.

Inclusion criteria were community-dwelling; aged 65yrs and over; functionally independent; medically stable; had sufficient ability in the English language to understand instructions; had the ability to hold a hand dynamometer; stand independently from sitting; and mobilise independently with or without a mobility aid. Participants were excluded if they had clinically visible lower limb oedema or lymphoedema; progressive neurological conditions; if

currently receiving treatment, or received treatment in the previous year, for cancer; or if they had significant cognitive impairment as judged by the functional knowledge of their GP.

Referrers provided potential participants with study information. Participants were thereafter invited to opt-into this study.

2.2. Ethical considerations

Ethical approval was granted by the Department of Health and Leisure Studies Research Ethics Committee, MTU Kerry on 2nd February 2022. Prior to data collection, written informed consent was obtained from all participants.

2.3. Outcome measures

Grip strength, chair stand test, gait speed, SPPB and TUG were selected as outcome measures due to their inclusion in EWGSOP2 [3]. All participants completed all tests. Height was measured to the nearest 0.5 cm using a portable Stadiometer (seca 213, Hamburg, Germany). Weight was measured (Kg) using a seated (seca 955, Hamburg, Germany) or standing scales (seca 875, Hamburg, Germany).

2.3.1. SARC-CalF

Participants completed an interview administered SARC-CalF questionnaire. Circumference of participants exposed right calf at the largest point with legs relaxed and bare feet 20 cm apart was measured twice with an inextensible anthropometric tape measure. Cut-off points for low CC muscle mass were ≤ 33 cm females and ≤ 34 cm males [29]. SARC-CalF scores of 11–20 signified probable sarcopenia.

2.3.2. Muscle strength

Lower limb muscle strength was assessed with the five times chair Sit-to-Stand Test (STS) [31], using EWGSOP2 cut-off point of >15 seconds. Isometric hand grip strength was measured with a Jamar hydraulic hand dynamometer (China, 12–0600) in the second handle position, following The American Society of Hand Therapists 2015 guidelines [32]. The mean of three measurements from the dominant and non-dominant hand were calculated, the higher mean was used in data analysis. EWGSOP2 cut-off points used were <27 kg males and <16 kg females.

2.3.3. Severity of sarcopenia

Physical performance outcome measures of gait speed, SPPB and TUG were assessed against EWGSOP2 cut-off points to investigate sarcopenia severity. Gait speed was assessed with participants walking 4-meters at usual walking speed. Walking distance exceeded 4-meters to permit acceleration from stationary and to prevent slowing before reaching the 4-meter mark [31]. Balance and gait speed components of the SPPB were completed [31]. Cut-off points for severe sarcopenia were ≤ 8 points for SPPB and ≤ 0.8 m/s for gait speed. The TUG was completed [33], with cut-off point ≥ 20 seconds.

2.4. Calculations

The following calculations were completed utilising sum scores to determine the probability of sarcopenia [24] and estimate the skeletal muscle mass index (SMMI) from anthropometric measurements [27].

Sum score formulae [24]:

Males: 0.62 × (age –64) –3.09 × (grip strength kg –50) –4.64 × (calf circumference cm –42)

Females: 0.80 × (age –64) –5.09 × (grip strength kg –34) –3.28 × (calf circumference cm –42)

Cut off Points for probability of sarcopenia were 101 male / 104 female (higher sensitivity) and 107 male / 118 female (higher specificity).

Percentage probability of sarcopenia formulae [24]:

Male probability = $1 / [1 + e^{-(\text{sumscore}/10-11.9)}]$

Female probability = $1 / [1 + e^{-(\text{sumscore}/10-12.5)}]$

Calculation of SMM [27]:

SMM (kg) = 0.244 x body weight (kg) + 7.8 x height (m) –0.098 x age (years) + 6.6 x gender + ethnics –3.3.

Values used were gender = 1 male, 0 female, ethnics = 0 white, all study population were white.

SMM values were adjusted by squared height to calculate SMMI.

Cut off Points for low SMMI were 6.72 kg/m^2 female and 6.85 kg/m^2 male as used previously [23].

2.5. Statistical analysis

Statistical analysis was completed using SPSS Statistics 27 (IBM Corp) and Microsoft Excel. Continuous data were reported as mean ± standard deviation and categorical variables as percentage (number). Normality of distribution was analysed using the Shapiro-Wilk test. Differences between groups for continuous normally distributed variables were analysed using the independent-samples *t*-test; and between non-parametric continuous variables using the Mann-Whitney *U* test. Associations were analysed using the Pearson's Chi-square test. Cohen's kappa (κ) was used to assess inter-rater agreement between categorical variables from operational definitions and between operational definitions and probable sarcopenia cut-off points. Magnitudes for Cohen's kappa (κ) [34] were: poor < 0, slight 0.00–0.20, fair 0.21–0.40, moderate 0.41–0.60, substantial 0.61–0.80 and almost perfect 0.81–1.00. p value < 0.05 was considered statistically significant [35].

3. Results

3.1. Participant characteristics

Participant characteristics are reported in Table 1. The population consisted of 68% ($n = 34$) females and 32% ($n = 16$) males. Average age was 77.29yrs (range 65.12–99.27yrs). The population mean SARC-F score was below the probable sarcopenia cut-off score. Population mean scores for both genders were not indicative of probable sarcopenia due to low muscle strength nor indictive of severe sarcopenia. The mean female score was above the higher sensitivity cut off from Ishii of 104 [24].

Sarcopenia related outcomes are reported in Table 1. Significant gender differences were noted for muscle mass and grip strength (females 19.60 kg/force, SD 5.56; males 33.83 kg/force, SD 7.95) ($p < 0.0005$).

3.2. Prevalence of sarcopenia

Prevalence rates of probable sarcopenia were influenced by the screening tool used, ranging from 10% (SARC-F) to 48% (STS) (Table 2). SARC-CalF identified significantly more males with probable sarcopenia ($p = 0.011$). SMMI equation [27] identified sarcopenia in 6% (grip+SMMI) and 24% (STS+SMMI). Although not identified in males, severe sarcopenia occurred in 0–17.6% of females depending on outcome measure.

3.3. Agreement between operational definitions of sarcopenia

Agreement between operational definition criteria was established to identify which criterion was

Table 1
Characteristics of study population and sarcopenia related population outcomes

	Total population	Female	Male	*P* value
Population Size	50	68 (34)	32 (16)	
Age (years)	77.29 (7.35)	77.40 (8.15)	77.06 (5.51)	0.883
Height (m)	1.63 (0.07)	1.60 (0.05)	1.70 (0.08)	<.0005*
Weight (kg)	71.29 (13.9)	66.88 (11.44)	80.66 (14.48)	0.001*
BMI (kg/m^2)	26.73 (5.13)	26.09 (4.97)	28.09 (5.34)	0.199
BMI 15–18.5 kg/m^2 (underweight)	2 (1)	2.9 (1)	0	
BMI 18.5–24.9 kg/m^2 (normal weight)	38 (19)	44.1 (15)	25 (4)	
BMI 25–29.9 kg/m^2 (overweight)	28 (14)	23.6 (8)	43.8 (7)	
BMI>30 kg/m^2 (obese)	32 (16)	29.4 (10)	31.2 (5)	
Calf circumference (cm)	35.7 (3.3)	35.45 (2.86)	36.28 (4.11)	0.410
Grip strength (kg/force)	24.15 (9.23)	19.60 (5.56)	33.83 (7.95)	<.0005*
STS (seconds)	21.53 (16.05)	21.09 (16.82)	22.47 (14.76)	0.546
Gait speed (m/s)	1.09 (0.31)	1.086 (0.32)	1.106 (0.31)	0.838
SBBP	9.36 (2.12)	9.29 (2.21)	9.50 (1.97)	0.833
TUG (seconds)	10.51 (4.1)	10.67 (4.37)	10.16 (3.50)	0.827
SARC-CalF Score	4.66 (5.05)	3.85 (4.53)	6.38 (5.81)	0.228
SARC-F Score	1.46 (1.75)	1.50 (1.78)	1.38 (1.75)	0.895
Ishii score	98.86 (36.18)	105.48 (34.85)	84.80 (36.00)	0.294
Ishii probability (%)	29.08 (1.87)	32.69 (36.35)	21.42 (31.90)	0.216
Lee SMMI (kg/m^2)	7.96 (1.87)	7.03 (1.22)	9.97 (1.34)	<.0005*

Mean (standard deviation) for age, height, weight and total BMI. % (N): % (number of participants) for population size and BMI categories. Leg strength assessed by chair stand test (STS). SPPB: short physical performance battery. TUG: Timed Up and Go Test. Lee SMMI (kg/m^2): skeletal muscle mass index calculated from Lee et al. [27]. *significant *p* value.

Table 2
Sarcopenia screening from anthropometric and performance-based operational definitions

	Total population	Male	Female	*p* value
Probable Sarcopenia (grip)	26 (13)	18.75 (3)	29.4 (10)	0.423
Probable Sarcopenia (STS)	48 (24)	56.25 (9)	44.12 (15)	0.423
Sarcopenia (grip and SMMI)	6 (3)	0	8.8 (3)	0.220
Sarcopenia (STS and SMMI)	24 (12)	18.75 (3)	26.5 (9)	0.551
Severe Sarcopenia (grip, SMMI + gait)	4 (2)	0	5.8 (2)	0.322
Severe Sarcopenia (grip, SMMI + SPPB)	6 (3)	0	8.8 (3)	0.220
Severe Sarcopenia (grip, SMMI + TUG)	0	0	0	
Severe Sarcopenia (STS, SMMI + gait)	6 (3)	0	8.8 (3)	0.220
Severe Sarcopenia (STS, SMMI + SPPB)	12 (6)	0	17.6 (6)	0.073
Severe Sarcopenia (STS, SMMI + TUG)	0	0	0	
Low gait speed EWGSOP2	22 (11)	12.50 (2)	26.47 (9)	0.266
Low SPPB EWGSOP2	30 (15)	31.25 (5)	29.40 (10)	0.895
Slow TUG EWGSOP2	4 (2)	0 (0)	5.88 (2)	0.322
Probable sarcopenia SARC-CalF	22 (11)	43.75 (7)	11.76 (4)	0.011*
Probable sarcopenia SARC-F	10 (5)	12.5 (2)	8.8 (3)	0.686
Probable sarcopenia Ishii 107/118	36 (18)	31.25 (5)	38.24 (13)	0.631
Probable sarcopenia Ishii 101/104	46 (23)	31.25 (5)	52.54 (18)	0.151
Low SMMI score	28 (14)	18.75 (3)	32.36 (11)	0.318
Low calf circumference	32 (16)	50 (8)	23.5 (8)	0.061

Data presented as % (N). Probable sarcopenia, sarcopenia and severe sarcopenia data derived using EWGSOP2 [3] operational definition. Ishii 107/118 and 101/104 refer to sum score cut-off values for sarcopenia from Ishii et al. [24]. Low SMMI indicates under cut-off score for low muscle mass calculated from Lee et al. [27] equation. *significant *p* value.

most accurate for screening. SARC-CalF had fair agreement with probable sarcopenia (STS) ($\kappa = 0.30$, $p = 0.011$) but did not agree with probable sarcopenia from grip measurement, gait-speed, SPPB or TUG. SARC-F had fair agreement with leg strength ($\kappa = 0.22$, $p = 0.014$) and moderate agreement with gait speed ($\kappa = 0.42$, $p = 0.001$) but did not agree with grip strength, SPPB or TUG (Table 3). The SARC-F and SARC-CalF questionnaires did not agree with each other (Table 4).

SMMI agreed moderately with leg strength ($\kappa = 0.43$, $p = 0.001$) and CC ($\kappa = 0.43$, $p = 0.002$), but did not agree with grip or severe sarcopenia outcome measures; signifying differences between upper and lower limb strength depending on SMM.

There was strong agreement between EWSGOP2 criteria and Ishii calculations [24]. Both Ishii cut-off scores and 50% probability calculation agreed more strongly with grip and leg strength than did SARC-CalF or SARC-F (Table 3). For both strength measures, gait speed and SPPB; Ishii 107/118 had higher agreement than 101/104 cut-off. Cut-off scores of 107/118 and 101/104 respectively agreed substantially ($\kappa = 0.77$, $p < 0.0005$) and moderately ($\kappa = 0.58$, $p < 0.0005$) with grip strength, having fair agreement with leg strength. Agreement was not found between questionnaires with Ishii calculations or between questionnaires with SMMI calculations (Table 4).

Ishii 50% probability calculation agreed substantially with grip strength ($\kappa = 0.80$, $p < 0.0005$), moderately with gait speed ($\kappa = 0.49$, $p < 0.0005$) and SPPB ($\kappa = 0.52$, $p < 0.0005$) and fairly with leg strength ($\kappa = 0.31$, $p = 0.019$) (Table 3).

Agreement between strength measures was not significant ($\kappa = 0.23$, $p = 0.075$). Leg strength agreed moderately with SMMI ($\kappa = 0.43$, $p = 0.001$). No agreement was found between grip strength and SMMI ($\kappa = 0.07$, $p = 0.646$). Of the two probable sarcopenia strength measures, grip strength agreed more strongly with Ishii scores, gait speed and SPPB; whereas leg strength agreed more strongly with SARC-CalF, SARC-F and CC.

EWGSOP2 physical performance measures agreed significantly; with strongest agreement between gait speed and SPPB ($\kappa = 0.49$, $p < 0.0005$).

Gait speed was the sole strength or physical performance measure which agreed significantly with both strength measures and the other two physical performance measures; having moderate agreement with grip strength ($\kappa = 0.45$, $p = 0.001$) and SPPB ($\kappa = 0.49$, $p < 0.0005$) and fair agreement with STS ($\kappa = 0.30$, $p = 0.011$) and TUG ($\kappa = 0.26$, $p = 0.007$). Gait speed had fair agreement with both Ishii cut-offs and moderate agreement with 50% probability ($\kappa = 0.49$, $p < 0.0005$).

Ishii calculations [24] agreed more with EWGSOP2 cut-off points for reduced strength and reduced

Table 3
Agreement between EWGSOP2 operational definition criteria of probable and severe sarcopenia with outcome measurements

Cohen's kappa	Low strength STS	Low strength grip	Slow gait speed	Low SPPB	Slow TUG
Low strength grip	κ=0.23, –0.02–0.47, $p = 0.075$		κ **= 0.45, 0.17–0.74,** p **= 0.001***	κ **= 0.41, 0.13–0.68,** p **= 0.004***	$\kappa = 0.07$, –0.14–0.28, $p = 0.430$
Low strength STS		$\kappa = 0.23$, –0.02–0.47, $p = 0.075$	κ **= 0.30, 0.08–0.53,** p **= 0.011***	$\kappa = 0.27$, –0.01–0.56, $p = 0.054$	$\kappa = 0.003$, –0.11–0.12, $p = 0.954$
Low SPPB	$\kappa = 0.27$, –0.01–0.56, $p = 0.054$	κ **= 0.41, 0.13–0.68,** p **= 0.004***	κ **= 0.49, 0.22–0.76,** p **< 0.0005***		κ **= 0.18, 0.07–0.40,** p **= 0.027***
Slow TUG	$\kappa = 0.003$, –0.11–0.12, $p = 0.954$	$\kappa = 0.07$, –0.14–0.28, $p = 0.430$	κ **= 0.26, 0.11–0.55,** p **= 0.007***	κ **= 0.18, –0.04–0.40,** p **= 0.027***	
Slow gait speed	κ **= 0.30, 0.08–0.53,** p **= 0.011***	κ **= 0.45, 0.17–0.74,** p **= 0.001***		κ **= 0.49, 0.22–0.76,** p **< 0.0005***	κ **= 0.26, –0.04–0.55,** p **= 0.007***
SARC-CalF $\geq$ 11	κ **= 0.30, 0.08–0.53,** p **= 0.011***	$\kappa = 0.13$, 0.05–0.20, $p = 0.375$	$\kappa = 0.05$, –0.31–0.21, $p = 0.729$	$\kappa = 0.18$, –0.11–0.46, $p = 0.205$	$\kappa = 0.07$, –0.16–0.02, $p = 0.443$
SARC-F $\geq$ 4	κ **= 0.22, 0.04–0.39,** p **= 0.014***	$\kappa = 0.09$, –0.18–0.36, $p = 0.452$	κ **= 0.42, 0.10–0.74,** p **= 0.001***	$\kappa = 0.06$, –0.18–0.30, $p = 0.607$	$\kappa = 0.24$, –0.20–0.69, $p = 0.054$
Low CC	κ **= 0.43, 0.19–0.67,** p **= 0.001***	$\kappa = 0.08$, –0.20–0.36, $p = 0.562$	$\kappa = 0.15$, –0.39–0.08, $p = 0.266$	$\kappa = 0.21$, –0.08–0.49, $p = 0.146$	κ = –0.08, –0.18–0.02, $p = 0.322$
>Ishii 107/118 cut-off	κ **= 0.35, 0.10–0.61** p **= 0.010***	κ **= 0.77, 0.58–1.00,** p **< 0.0005***	κ **= 0.38, 0.12–0.65,** p **= 0.004***	κ **= 0.41, 0.15–0.68,** p **= 0.003***	$\kappa = 0.03$, –0.12–0.18, $p = 0.674$
>Ishii 101/104 cut-off	κ **= 0.32, 0.06–0.58,** p **= 0.025***	κ **= 0.58, 0.37–0.79,** p **< 0.0005***	κ **= 0.33, 0.10–0.56,** p **= 0.007***	κ **= 0.34, 0.09–0.59,** p **= 0.011***	$\kappa = 0.01$, –0.11–0.12, $p = 0.908$
Ishii 50% prob	κ **= 0.31, 0.06–0.56,** p **= 0.019***	κ **= 0.80, 0.62–0.99,** p **< 0.0005***	κ **= 0.49, 0.22–0.76,** p **< 0.0005***	κ **= 0.52, 0.27–0.78,** p **< 0.0005***	$\kappa = 0.05$, –0.13–0.23, $p = 0.529$
Low SMMI score	κ **= 0.43, 0.20–0.66,** p **= 0.001***	$\kappa = 0.07$, –0.33–0.20, $p = 0.646$	$\kappa = 0.10$, –0.19–0.39,p=0.484	$\kappa = 0.27$, –0.01–0.56, $p = 0.054$	$\kappa = 0.06$, –0.14–0.79, $p = 0.479$

Cohen's kappa (κ), 95% confidence interval range and p value. Leg strength measured by five times chair sit to stand test (STS). SPPB: short physical performance battery. TUG: Timed Up and Go test. Ishii 107/118 and Ishii 101/104 refers to sum score cut-off values, >Ishii cut-off score indicates more likely to have sarcopenia [24]. Ishii 50% prob: 50% probability of sarcopenia [24]. Low SMMI indicates under cut-off score for low muscle mass, indicating low muscle mass [27]. CC: calf circumference. *significant p value.

Table 4
Agreement between operational definitions of sarcopenia with cut-off points from SARC-CalF, SARC-F, calf circumference, SMMI and Ishii [24] calculations

Cohen's kappa	positive SARC-CalF ≥ 11	positive SARC-F ≥ 4	Under CC cut-off	Low SMMI score	>Ishii 107/118 cut-off	>Ishii 101/104 cut-off	probability Ishii 50%
SARC-CalF ≥ 11		$\kappa = -0.01$, –0.26–0.23, $p = 0.909$	**$\kappa = 0.75$, 0.55–0.95, $p < 0.0005$***	$\kappa = 0.20$, –0.09–0.50, $p = 0.144$	$\kappa = 0.10$, –0.17–0.37, $p = 0.459$	$\kappa = 0.080$, –0.16–0.32, $p = 0.520$	$\kappa = 0.07$, –0.21–0.35, $p = 0.602$
SARC-F ≥ 4	$\kappa = -0.01$, –0.38–0.10, $p = 0.909$		$\kappa = -0.07$, –0.26–0.13, $p = 0.544$	$\kappa = 0.05$, –0.26–0.16, $p = 0.675$	$\kappa = 0.12$, –0.10–0.35, $p = 0.239$	$\kappa = 0.15$, –0.04–0.33, $p = 0.108$	$\kappa = 0.06$, –0.18–0.30, $p = 0.607$
Low CC	**$\kappa = 0.75$, 0.55–0.95, $p < 0.0005$***	$\kappa = -0.07$, –0.26–0.13, $p = 0.544$		**$\kappa = 0.43$, 0.16–0.70, $p = 0.002$***	**$\kappa = 0.29$, 0.01–0.56, $p = 0.041$***	$\kappa = 0.22$, –0.05–0.48, $p = 0.108$	**$\kappa = 0.21$, –0.08–0.49, $p = 0.146$***
>Ishii 107/118 cut-off	$\kappa = 0.10$, –0.17–0.37, $p = 0.459$	$\kappa = 0.12$, –0.10–0.35, $p = 0.239$	**$\kappa = 0.29$, 0.01–0.56, $p = .041$***	$\kappa = 0.18$, –0.10–0.46, $p = 0.198$		**$\kappa = 0.80$, 0.63–0.96, $p < 0.0005$***	**$\kappa = 0.87$, 0.72–10.01, $p < 0.0005$***
>Ishii 101/104 cut-off	$\kappa = 0.08$, –0.16–0.32, $p = 0.520$	$\kappa = 0.15$, –0.04–0.33, $p = 0.108$	$\kappa = 0.22$, –0.05–0.48, $p = 0.108$	$\kappa = 0.13$, –0.13–0.39, $p = 0.324$	**$\kappa = 0.80$, 0.63–0.96, $p < 0.0005$***		**$\kappa = 0.67$, 0.47–0.87, $p < 0.0005$***
Ishii 50% prob	$\kappa = 0.07$, –0.21–0.35, $p = 0.602$	$\kappa = 0.06$, –0.18–0.30, $p = 0.607$	$\kappa = 0.21$, –0.08–0.49, $p = 0.146$	$\kappa = 0.08$, –0.21–0.36, $p = 0.582$			
Low SMMI score	$\kappa = 0.20$, –0.09–0.50, $p = 0.144$	$\kappa = -0.05$, –0.26–0.16, $p = 0.675$	**$\kappa = 0.43$, 0.16–0.70, $p = 0.002$***		$\kappa = 0.18$, –0.10–0.46, $p = 0.198$	$\kappa = 0.13$, –0.13–0.39, $p = 0.324$	$\kappa = 0.08$, –0.21–0.36, $p = 0.582$

Cohen's kappa (κ), 95% confidence interval range and p value. >Ishii cut-off score indicates more likely to have sarcopenia. Ishii 50% prob: 50% probability of sarcopenia as per Ishii et al. [24] calculation. Ishii 107/118 and Ishii 101/104 refer to sum score cut-off values [24]. Low SMMI indicates under cut-off score for low muscle mass, indicating low muscle mass [27]. CC: calf circumference. *significant p value.

physical performance compared to both SARC-CalF and SARC-F. Calculated SMMI [27] agreed significantly with reduced CC, indicating this calculation may enable assessment of muscle quantity in primary care (Table 4).

4. Discussion

Prevalence rates of probable sarcopenia, sarcopenia, and severe sarcopenia varied depending on outcome measures used, as reported previously [36]. Probable sarcopenia prevalence was 22% and 10% using SARC-CalF and SARC-F respectively. SARC-CalF and SARC-F rates of probable sarcopenia were comparable to Yang et al. [37] in a similar population of 25.8% and 12.2% respectively.

It is important to establish which screening tools are most accurate for the population tested. Inappropriate screening tool selection, with resultant variable prevalence rates, may impact screening accuracy by increasing the risk of missing individuals with sarcopenia; possibly resulting in unnecessary referrals for diagnostic procedures and delayed sarcopenia presentations.

This study investigated agreement between questionnaires (SARC-CalF and SARC-F) with EWGSOP2 probable sarcopenia criteria. Although SARC-CalF had fair agreement with leg strength, SARC-CalF did not agree significantly with grip strength or physical performance measures of severe sarcopenia. In contrast, and as reported [38], this study found SARC-F had greater agreement with leg strength and gait speed than grip strength; therefore SARC-F may be beneficial clinically to monitor changes in lower limb physical ability.

CC, the most sensitive anthropometric muscle mass measurement in the elderly [39], was recommended by EWGSOP2 as a diagnostic proxy when other diagnostic methods are unavailable and enhances diagnostic accuracy when used in conjunction with other parameters [40]. Whereas SARC-CalF requires CC cut-off points, the Ishii formulae [24] using CC does not. The current study provided evidence of this, as the Ishii formulae including CC, age and grip strength; agreed significantly with all EWGSOP2 strength and physical performance outcome measurements.

Landi et al. [41] reported associations between CC with grip strength and SPPB but cited limitations due to body fat and fluid changes. In this current study, low CC had fair agreement with low STS but not grip strength. Improving CC accuracy by adjusting for lower limb oedema [42] and BMI [43] are recommended. As the BMI of 55.9% of females and 75% of males in this study were outside normal BMI ranges [44], adjusting for CC may have improved accuracy.

Probable sarcopenia grip and leg strength measures did not agree ($\kappa = 0.23$, $p = 0.075$), indicating that choice of outcome measure influenced probable sarcopenia diagnosis. One explanation is grip strength is a poor surrogate for leg strength [45], explaining approximately 40% of leg strength [46]. Age-related strength loss profiles differ for upper and lower limbs [47]. With age, lower body muscle mass decreases more [48] and leg strength declines more [47]. This may explain why SMMI agreed moderately with leg strength (STS) but not with grip strength. Agreement between SMMI calculations and leg strength may have practical implications regarding resources needed to calculate SMMI for this population within primary care.

Leg strength may better identify stage of sarcopenia [45]. However, EWGSOP2 algorithm indicates that 48% of the current population should be referred for muscle assessment due to STS results, with resourcing implications. In contrast, measuring grip strength as the sole strength measure, may delay commencement of interventions with individuals presenting in more sarcopenic states which may negatively influence outcomes. As a solution, assessing leg and grip strength are recommended [49].

Sarcopenia effects genders differently [50] and grip strength may not identify slight differences in associations between leg strength and function [51]. These findings, combined with age related limb strength profile, may explain why significant gender differences were noted for grip but not leg strength.

In contrast, STS is reliable for case-finding probable sarcopenia [52]. Within this study, probable sarcopenia due to low STS strength agreed with EWGSOP2 physical performance measures of slow gait speed; whilst low grip strength agreed with physical performance measures of SPPB and slow gait speed. SMMI agreed moderately with probable sarcopenia as assessed by STS but not with grip strength. Grip strength and STS cut-off points may have influenced these findings. Compared to Irish data [53], EWGSOP2 derived grip cut-off points [54], were approximately 15% higher; therefore probable sarcopenia in this current study may be overestimated. The average age from which EWGSOP2 STS cut-off points were based [55] was 73.6yrs, compared to 77.3yrs in this study, which may have influenced accuracy.

Physical performance is a key predictor of adverse health outcomes due to sarcopenia [56]. Hospital admission rates correlate significantly with gait speed, SARC-F and Ishii's formulae [57]. Grading severity of sarcopenia using physical performance measures of SPPB [21] or gait speed [52] is recommended. Although gait speed did not agree with SARC-CalF; gait speed agreed with SARC-F, all EWGSOP2 strength and physical performance measures and all Ishii calculations. Therefore, gait speed is the preferred physical performance measure for assessing sarcopenia severity in this population.

When Ishii's Japanese developed screening tool, was used with Caucasian in-patient's, the probability of sarcopenia was found to be associated with reduced physical function [58]. Within this study, Ishii calculations agreed with STS, grip strength, SPPB and gait-speed. Use of absolute values for grip strength and CC within the Ishii formulae, may have increased agreement as population specific cut-off points were not required.

This studies results cannot be extrapolated beyond the population tested. As participants opted-in, recruitment bias due to health literacy is possible. Not using locally validated SARC-CalF cut-off points within this study as recommended [59] may have influenced results; as may using EWGSOP2 rather than population specific cut-off points; neither cut-off points were available. Irish data [53] based on a population aged 50yrs and over, was not representative of the tested population. Despite these limitations, this study provides information which may be valuable when screening community-dwelling older adults for sarcopenia.

Screening for sarcopenia using a combination of a questionnaire with a screening tool for muscle mass and function is recommended [60] and may be suitable for the population studied. The following model is recommended within primary care:

1. SARC-F or SARC-CalF use with leg strength (STS) to identify probable sarcopenia. Population specific CC cut-off points or adjusting CC for BMI or limb oedema may increase accuracy of SARC-CalF with community-dwelling older adults.
2. Thereafter, Ishii et al. [24] tool is recommended, using formulae to calculate probability or sum score cut-off values. Grip strength is not recommended as the sole strength measurement due to risk of delayed interventions. If using a single strength screening measurement, it should be from the lower limb to enable early intervention. If a handgrip dynamometer is unavailable for calculating Ishii formulae, strength should be assessed using STS.
3. Within primary care if diagnostic equipment is unavailable, Lee et al. [27] formula may enable SMM assessment.
4. To quantify sarcopenia severity, gait speed is the preferred outcome measure, due to agreement with EWGSOP2 measures, Ishii scores and SARC-F.

SARC-F may be beneficial for telehealth due to significant agreement with gait speed.

Research is warranted regarding clinical assessment methods which most accurately diagnose sarcopenia and which measure of probable sarcopenia most accurately predicts sarcopenia progression [61]. Population specific cut-off points may improve screening accuracy. Establishing the ability of Ishii probability calculation to respond to interventions and development of a universally accepted definition or criteria for sarcopenia diagnosis to enable comparison between studies maybe beneficial.

Conflict of interest

The authors have no conflict of interest to report. No funding was received for this study.

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